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AN EXPERIMENT WITH MULTI-AGENT SYSTEM IN VIRTUAL LEARNING ENVIRONMENT

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Abstract. Educational institutions that work with distance education courses increasingly have the task of monitoring the activities of students by tutors and facilitators aiming to achieve better levels of quality. This paper describes an experiment conducted with students from one technical online course. The experiment used a Multi-Agent Systems (MAS) that applied the concept of perception, designed to help students and tutors on completion and monitoring their activities during distance education courses. The concept of perception employed by MAS ensures that the participants are aware of their own and the other participants' actions, thus reducing the time spent on work activities and allowing a better learning assessment. The MAS developed following the proposed model, and helped students and tutors to solve problems related to the course through a discussion forum. It also suggested the completion of unfinished activities for the students, providing a smoother running of the course and increasing the collaboration of other participants. The results obtained from the experiment showed that the proposed model of Multi-Agent Systems in Virtual Learning Environments helped the course participants perform their assignments. Furthermore, it showed that it can be used as an effective tool for monitoring the activities of students by tutors during online courses.

Keywords: AIML, JADE, VLE, Multi-Agent Systems, perception.

Introduction

The interaction between people and environment in a classroom situation obtains excellent results because the senses help students to perform activities. However in virtual learning environments learner perception is different and needs to be stimulated. Collaborative online learning environments should provide the elements of perception necessary for cooperative and individual work equivalent to those in environments where sense perception is used. Individuals should be able to share their knowledge and arrange themselves so that their own efforts help other participants.

Online support tools like discussion forums, have monitoring limitations due to the number of messages that do not receive feedback from the student. This response delay affects the performance of the course, discouraging students and increasing the amount of school evasion. Another problem faced by tutors and students is the lack of tools to monitor the ways in which students carry out activities. On the other hand, when students know what assignment they have done and what assignment has been done by other participants, cooperation is improved and positive results may be brought for the group, as it helps students finish their assignments.

This paper presents an experiment with the multi-agent system (MAS), proposed by Alencar and Netto (2011). In this work the authors developed a MAS which works in a Virtual Learning Environment (VLE) through a discussion forum on Moodle, using AIML (Artificial Intelligence Markup Language) and JADE framework (Java Agent Development Framework). In VLEs the MAS is represented by an Assistant Tutor who helps the Distant Tutor monitoring the students.

There are several studies using agents in virtual learning environments, such as KDMAS (Multi Agent System for Knowledge Discovery) which works on the knowledge acquisition in an organization learning environment and explores databases containing information about the business activities of an organization (Jin and Decker

2006).

Huang et al. (2007) using the Moodle platform performed a study about individuals' learning style: independent, dependent, competitive, collaborative, avoidant and participant. He developed a diagnostic agent to analyze each learner's learning portfolio in the e-learning platform and automatically issue feedback messages in cases when some learner's behaviors did not fit their learning styles.

Multiagent System Architecture

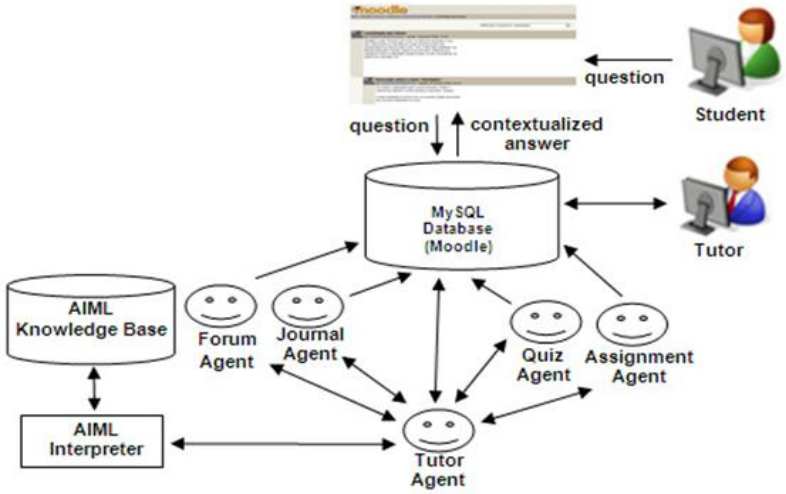

Fig. 1. Multiagent System Architecture

The architecture of the work (Figure 1) comprises the student, the distance tutor, the Moodle forum, the MySQL Database, the AIML interpreter, the AIML knowledge base and the MAS. The MAS is comprised of six intelligent agents: The Forum Agent, who is responsible for constantly collecting the questions posted by the students on the forum and identifying the students who have not posted; the Journal Agent, who is responsible for verifying if the student has accomplished the journal activity; the Quiz Agent, who is the person in charge of verifying if the student has accomplished the quiz activity; the Assignment Agent, who is the person in charge of verifying if the student has sent the assignment; and the Tutor Agent who receives information from the four previous agents and creates a final contextualized answer.

The process begins when the student posts a question on the forum. The Tutor Agent reads the question, sends it to the AIML interpreter. He is in turn responsible for finding the answer to the question and returning the result to the Tutor Agent. Meanwhile, the other agents give feedback on the status of the student assignment to the Tutor Agent, who is in charge of creating a contextualized answer. This includes the answer to the question and praise for the student, if he/she is up to date with the activities. If the student is behind schedule or hasn't accomplished the assignment a recommendation for action is sent.

The same AIML technology used in the experiment described below, was used by Batista et al. (2010). In his research he developed a chatterbot inserted in a Virtual Learning Environment (VLE) to solve questions about JAVA language. The use of chatterbots as virtual assistants can be encouraging to students, decreasing their feeling of loneliness, which occurs frequently when students use VLEs.

Alencar and Netto's research (2011) presented the implementation and experiments using a CyberPoty chatterbot, a virtual assistant which also uses AIML knowledge base to answer questions about the technical courses of CETAM EAD.

Perception

Cooperative learning in Virtual Learning Environments benefits from users' perceptions of the learning environment. Through these perceptions, they possess knowledge about the activities that have been accomplished by the other participants of the course. These perceptions also ensure that the participants comprehend, or are aware of the whole learning process and of the interactions among the students, thereby

helping their development.

Virtual Learning Environments that use the concept of perception, help tutors monitor their students. This resource promotes better individual assessment. The knowledge of each student action, such as development, learning and interaction with other participants, also helps tutors take decisions, enabling better learning assessment.

According to Fuks et al. (2002), in the 3C cooperation model, the perception element establishes a connection involving communication, coordination and cooperation. To coordinate the students it is necessary to obtain information about what is happening in the group. If collaboration exists it is easier to take necessary decisions and enables cooperation. Dialogue creates perception channels implied in communication. Cooperation enables the participants to work together aiming for the same target.

Lima et al. 2010 developed the ARARA project (Artifacts and Requirement Awareness Reinforced Agents), which applied the concept of perception in order to help a team develop a software project. He noticed that researchers needed to know what the other members of the team were doing so that the whole project was successfully established. The MAS applied in the project was able to detect changes to the artifacts, isolate the affected artifacts and notify the members about the detected changes and artifacts that needed to be modified.

The research of Dochy (2005) presented a study about the different perceptions among groups of students. It concluded that to understand the students' learning process and to succeed in learning it is necessary for the environment to use resources that enable student perception.

In Virtual Learning Environments, collaborative learning benefits from the perception that users have of the environment, knowing what activities were performed by other course participants. The concept of perception ensures that participants understand or have knowledge of the process itself and the interaction of students, ultimately contributing to their development in distance education environments.

VLEs that use perception to assist teachers in monitoring student, because this feature with the individual evaluation is facilitated. Knowing the actions of students, such as development, learning and integration with other participants, helps in decision making, enabling a better assessment of learning.

The work of Arafa and Mamdani (2000) presented an MAS that used perception by communication among agents. Because of the exchange of messages used by the agents is possible to have knowledge about users and the environment in real time.

Lima et al. (2010) developed the project ARARA (Artifacts and Requirement Awareness Reinforced Agents), which applied the concept of perception to help a team software development project. He noted that developers needed to know what the other team members were doing in order for the overall design to succeed . This MAS was able to sense changes in artifacts, recover the related artifacts and notify members about perceived changes and artifacts to be modified.

Gouveia (2011) presented a framework using perception to understand students' learning and learners and discovered that it is necessary to use technological resources in the environment.

Experiments

The MAS experiment was conducted during an "Introduction to Digital Media" course, with a duration of 20 hours, from July 04 2011 to July 18 2011. Thirty six students from the Technical Maintenance Course in Computer Support of CETAM EAD, in the cities of Manaus and Eirunepé in Amazonas, Brazil took part.

The "Introduction to Digital Media" course, available at http://ead.cetam.am.gov.br/salainfo/ , was monitored by distant tutors and the Assistant Tutor (representing the MAS) and had four scored tasks: Forum, Assignment, Quiz and Journal. The first assignment was the forum where students should post each one a question about Digital Media. In this activity the researchers developed a knowledge base containing approximately 1000 AIML rules, each rule containing a definition of computer equipment. Principal hardware items were selected with some variations in question types.

The second assignment was the task of sending a single file, where students were required to write an essay about either collective purchases on the Internet, cyberbullying, or safety on the Internet. In the third assignment the students were required to answer a quiz about social networks. The fourth and final assignment was a Journal about Digital TV, where the student should register their knowledge about a known subject after watching a video about the subject.

After the end of the course we evaluated students' participation levels in each assignment. During the forum, named "Questions about Digital Media", 28 messages were posted and 11 of these were answered by the Assistant Tutor, corresponding to 40% of the posted messages. The questions (highlighted) of two students are

shown on Figure 2, and they both received replies from the MAS to their questions. As the first student was up to date with the activities according to the schedule, he/she received a compliment in their reply, as shown in the sentence: "KADSON I can see you are up to date with your assignment(s), congratulations, keep it up.". As the second student had delayed his assignments, there were recommendations in the reply, as shown in this part of the reply: "ANTONIO I can see you haven't sent the assignment yet and haven't answered the quiz"

Re: Fórum 1 - Dúvidas sobre mídias digitais
por KADSON SANTOS DA SILVA - terça, 5 julho 2011, 07:47
olá a todos, como vários colegas comentaram alguns são novidades por serem lançamentos e outros do nosso cotidiano já sabemos manusear, oque é diferente de conhecer como aquilo funciona, creio que muitos colegas como eu sabem manusear o equipamento mas na maioria não sabe como funciona.
uma duvida ?
-como funciona a tecnologia do Blu-ray.(acho que e assim que se escreve)
Mostrar principal | Editar | Excluir | Responder
Nota máxima: 30 / 30
Re: Fórum 1 - Dúvidas sobre mídias digitais
por Tutor Auxiliar - quarta, 6 julho 2011, 18:31
Blu-ray é um formato de disco óptico da nova geração de 12 cm de diâmetro (igual ao CD e ao DVD) para vídeo de alta definição e armazenamento de dados de alta densidade. É uma alternativa ao DVD e é capaz de armazenar filmes até 1080p Full HD de até 4 horas sem perdas. Requer uma TV full HD de LCD, plasma ou LED para explorar todo seu potencial KADSON Verifiquei que você está em dia com sua(s) atividade(s), Parabéns continue assim.
Re: Fórum 1 - Dúvidas sobre mídias digitais
por ANTÔNIO JAIRO FERREIRA GUILHERME - quinta, 7 julho 2011, 20:26
Após estudar e analisar o material disponibilizado entendi mais profundo como funcionam as mídias digitais. Já venho utilizando várias mídias digitais há muito tempo, mais uma nova que surgiu no mercado recentemente, são os novos televisores de LED e LCD das empresas LG, SAMSUNG e da SONY, que já vem com um mini-teclado e acesso a internet e ainda disponibilizar acesso a rede sem fio através de um roteador. Gostaria que o professor comenta-se um pouco sobre essa nova mídia digital.
Mostrar principal | Editar | Excluir | Responder
Nota máxima: 30 / 30
Re: Fórum 1 - Dúvidas sobre hardware
por Tutor Auxiliar - segunda, 11 julho 2011, 16:32
LCD (Liquid Crystal Display) ou Tela de cristal líquido.LED (Light Emitting Diode) ou diodo emissor de luz, sua função básica é a emissão de luz em locais onde se torna mais conveniente a sua utilização no lugar de uma lâmpada.
ANTÔNIO verifiquei que você ainda não enviou a atividade e não fez o questionário.

Fig. 2. Agents answering questions

During the analysis of the Forum, one of the problems encountered by the Assistant Tutor when answering questions from the students, was that the received messages contained paragraphs that were too long. They contained several AIML knowledge based words, complicating the work of the AIML interpreter. Figure 3 shows some messages (highlighted) posted on the forum by students with these characteristics.

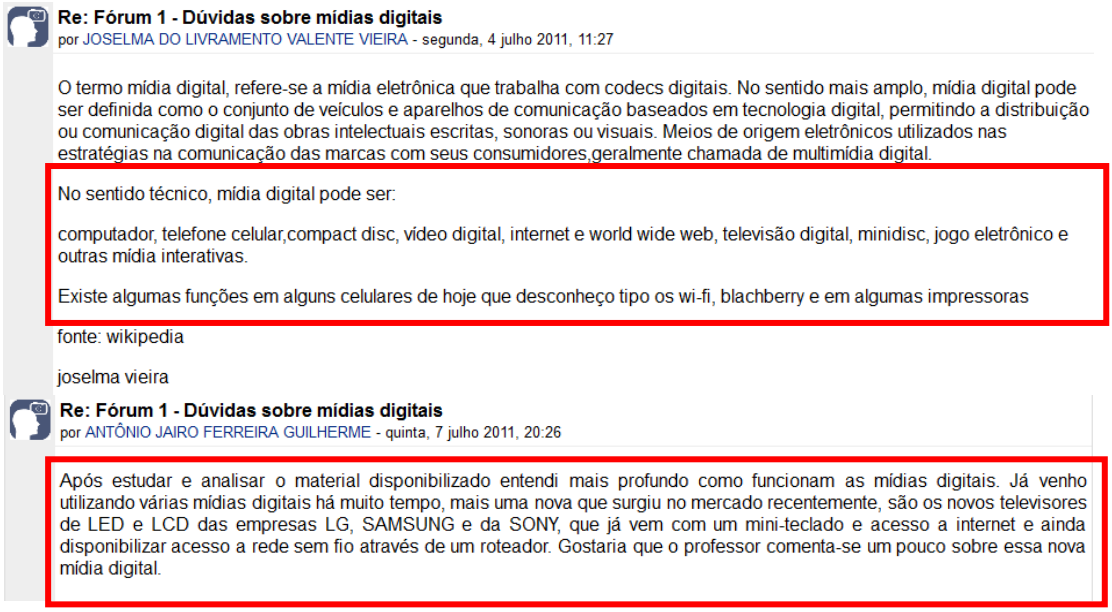
Re: Fórum 1 - Dúvidas sobre mídias digitais
por JOSELMA DO LIVRAMENTO VALENTE VIEIRA - segunda, 4 julho 2011, 11:27
O termo mídia digital, refere-se a mídia eletrônica que trabalha com codecs digitais. No sentido mais amplo, mídia digital pode ser definida como o conjunto de veículos e aparelhos de comunicação baseados em tecnologia digital, permitindo a distribuição ou comunicação digital das obras intelectuais escritas, sonoras ou visuais. Meios de origem eletrônicos utilizados nas estratégias na comunicação das marcas com seus consumidores,geralmente chamada de multimídia digital.
No sentido técnico, mídia digital pode ser:
computador, telefone celular,compact disc, vídeo digital, internet e world wide web, televisão digital, minidisc, jogo eletrônico e outras mídia interativas.
Existe algumas funções em alguns celulares de hoje que desconheço tipo os wi-fi, blachberry e em algumas impressoras
fonte: wikipedia
joselma vieira
Re: Fórum 1 - Dúvidas sobre mídias digitais
por ANTÔNIO JAIRO FERREIRA GUILHERME - quinta, 7 julho 2011, 20:26
Após estudar e analisar o material disponibilizado entendi mais profundo como funcionam as mídias digitais. Já venho utilizando várias mídias digitais há muito tempo, mais uma nova que surgiu no mercado recentemente, são os novos televisores de LED e LCD das empresas LG, SAMSUNG e da SONY, que já vem com um mini-teclado e acesso a internet e ainda disponibilizar acesso a rede sem fio através de um roteador. Gostaria que o professor comenta-se um pouco sobre essa nova mídia digital.

Fig. 3. Long answers

When checking the posted messages, we observed that one student included the words: computer, telephone, mobile, compact disc, Internet, digital television, etc. Another student mentioned: LED, LCD, mini-keyboard, Internet, etc. These long paragraphs confounded (or caused confusion to) the AIML interpreter, forcing it to create several different answers, one for each mentioned word. Although it was not the main purpose of this work, this problem was solved by making adjustments to the AIML interpreter. In the early days of the implementation and monitoring of the MAS, we found some flaws in the system:

- Some students posted their messages on the forum using long paragraphs with several "keywords", causing confusion to the AIML interpreter, which replied with wrong answers.
- Some messages sent to the Distant Tutor did not show the real status of the student, reporting non-accomplished activities that had not yet been made available to students.
- The Distant Tutor did not know how to properly formulate his questions to the Assistant Tutor, making it difficult to monitor the activities of one or more students in the Virtual Learning Environment.
- The MAS reply in the forum did not include the name of the student, making it difficult for the other participants to know who was getting recommendations or praise.
- If students were up to date with their activities, the MAS always generated the same motivation reply.

After these mistakes manifested themselves, the MAS program was stopped the necessary corrections were made to the source code and the MAS operation was available again.

To solve the problem of long paragraphs with more than one rule, the AIML interpreter was programmed to accept only one rule. If the wrong status was registered, the behavior of the Tutor Agent was modified so that it monitored only the duration of each assignment according to the course schedule.

In the second part of the contextualized answer posted on the forum, the name of the student was added. We also made changes to the motivation reply, generating five different phrases turning the environment into a more human one. To get to this result, we added a variable named “Sentence” to the source code of the Tutor Agent, as in: Sentence= Student'sName + "I checked that you" + AnswerVector[x];

The answer vector started working with the values shown below and for each answer of the MAS, the index of the vector was changed randomly:

AnswerVector[0]= “you are up to date with your assignment (s). Congratulations, keep it up”;
AnswerVector[1]= “you accomplished all the assignments , excellent, you are on the right track”;
AnswerVector[2]= “you are accomplishing the course schedule, your performance is very good”;
AnswerVector[3]= “you are on the right track, your activities are up to date. Congratulations on your effort”;
AnswerVector[4]=“you are accomplishing your activities within the time limit set, you're an excellent student”.

In order to find out students' opinions about the course, we developed an evaluation questionnaire with eleven questions and multiple-choice answers as follows: CD (completely disagree), DIP (Disagree in part), NAND (Neither agree nor disagree), AIP (Agree in part) and SA (Strongly Agree). This questionnaire was made available at the beginning of the course and each student was asked to complete it after finishing their activities.

After the end of the course, 25 students answered the questionnaire, corresponding to about 70% of the participants. After gathering the data, all the answers were collated and the results displayed, as shown in Table 1.

Table 1. Assessment Results

ASSESSMENT RESULTS	ANSWERS				
QUESTIONS	SA	AIP	NAND	DIP	CD
1) The reply sent by the Assistant Tutor through the Forum, answered my questions properly.	13	9	2	1	0
2) Observations made by the Assistant Tutor on the Forum motivated me to accomplish my assignments	18	7	0	0	0
3) The Assistant Tutor helped to improve the quality of the discussion on the forum.	15	8	1	1	0
4) Messages sent by the distant tutor motivated me during the course	17	7	1	0	0
5) The course assignments were clear and objective.	21	4	0	0	0
6) The course supportive materials (files, video and animation) were sufficient to explain the subjects.	16	6	1	1	1
7) The deadline to perform the assignments was appropriate.	17	8	0	0	0
8) The course provided me some new knowledge	23	2	0	0	0
9) I was interested in performing my assignments.	12	12	1	0	0
10) I received feedback quickly	19	5	1	0	0
11) I often accessed the course resources	8	11	2	4	0

Analyzing the results shown in Table 1 we can see that 13 students answered “strongly agree” in the first question, (52%), while 9 students answered “Agree in part” (36%) as presented in Figure 4a.

In the second question, we can see that 18 students answered “strongly agree” (72%), while 7 students answered “Agree in part” (28%) as presented in Figure 4b.

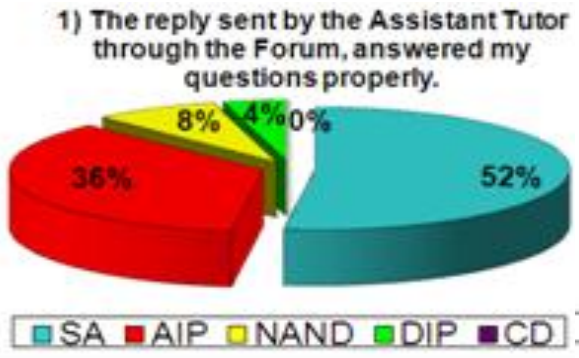

Fig. 4a. First question

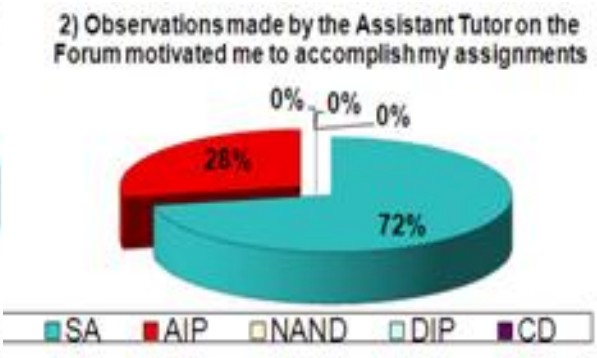

Fig. 4b. Second question

The MAS had another role beside managing the forum and monitoring the students' assignments. It also provided help to the Distant Tutor through the Assistant Tutor. This action happened with the use of messages where the Assistant Tutor provided information about the status of one or more students during the course, as shown in Figures 5a e 5b.

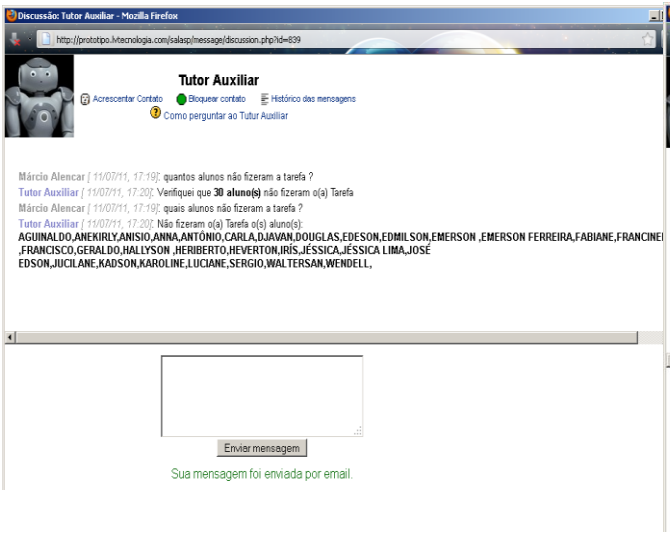
Discussão: Tutor Auxiliar - Mozilla Firefox
http://prototipo.ivtecnologia.com/salasp/message/discussion.php?id=839
Tutor Auxiliar
Acrescentar Contato
Bloquear contato
Histórico das mensagens
Como perguntar ao Tutor Auxiliar
Márcio Alencar [11/07/11, 17:19]: quantos alunos não fizeram a tarefa ?
Tutor Auxiliar [11/07/11, 17:20]: Verifiquei que 30 aluno(s) não fizeram o(a) Tarefa
Márcio Alencar [11/07/11, 17:19]: quais alunos não fizeram a tarefa ?
Tutor Auxiliar [11/07/11, 17:20]: Não fizeram o(a) Tarefa o(s) aluno(s):
AGUINALDO,ANEKIRLY,ANISIO,ANNA,ANTÔNIO,CARLA,DJAVAN,DOUGLAS,EDESON,EDMILSON,EMERSON ,EMERSON FERREIRA,FABIANE,FRANCINE
,FRANCISCO,GERALDO,HALLYSON ,HERIBERTO,HEVERTON,IRÍS,JÉSSICA,JÉSSICA LIMA,JOSÉ
EDSON,JUCILANE,KADSON,KAROLINE,LUCIANE,SERGIO,WALTERSAN,WENDELL,
Enviar mensagem
Sua mensagem foi enviada por email.

Fig. 5a. Distant Tutor Asking to the Assistant Tutor

Discussão: Tutor Auxiliar - Mozilla Firefox
http://prototipo.ivtecnologia.com/salasp/message/discussion.php?id=839
Tutor Auxiliar
Acrescentar Contato
Bloquear contato
Histórico das mensagens
Como perguntar ao Tutor Auxiliar
Márcio Alencar [18/07/11, 10:14]: O aluno Victor fez o questionário ?
Tutor Auxiliar [18/07/11, 10:15]: Sim, VICTOR participou do Questionário, postando em 16/07/2011 20:08:18
Enviar mensagem
Sua mensagem foi enviada por email.

Fig. 5b. Question about a single student

The messages sent to the Assistant Tutor needed to follow a standard. Thus, six interrogative sentences were created enabling the Distant Tutor to have better knowledge of the information required:

- How many students haven't accomplished the [assignment title]?
- Which student hasn't accomplished the [assignment title]?
- Who hasn't accomplished the [assignment title]?
- [Student's name] has accomplished the [assignment title]?
- Which assignment [student's name] hasn't accomplished?
- The student [student's name] has accomplished the [assignment title] ?

In order to know how to make questions to the Assistant Tutor about the students, the Distant tutor was provided with an extra link to the Moodle message ("How to make questions to the Assistant Tutor") only visible on the Assistant Tutor profile. It showed another page with six ways of asking questions, as presented in Figure 6.

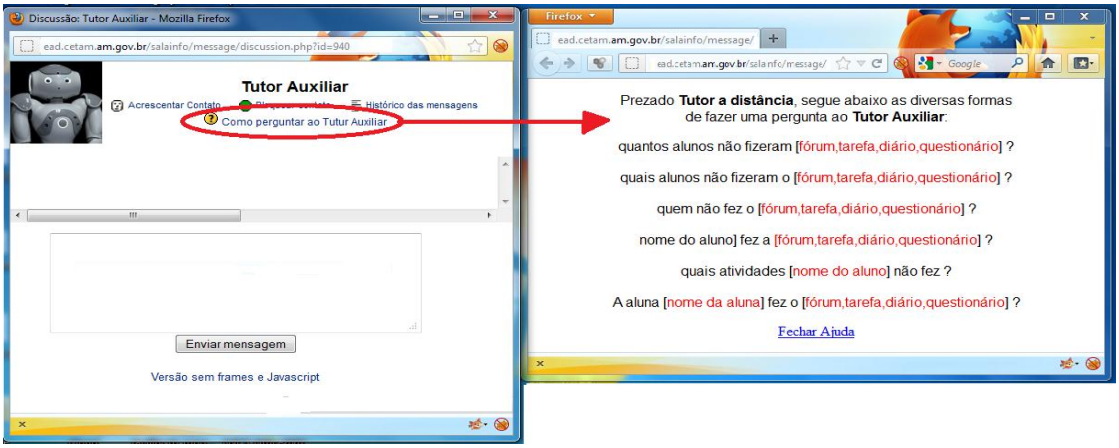
Discussão: Tutor Auxiliar - Mozilla Firefox
ead.cetam.am.gov.br/salainfo/message/discussion.php?id=940
Tutor Auxiliar
Acrescentar Contato
Histórico das mensagens
Como perguntar ao Tutur Auxiliar
Enviar mensagem
Versão sem frames e Javascript
Firefox
ead.cetam.am.gov.br/salainfo/message/
Prezado Tutor a distância, segue abaixo as diversas formas de fazer uma pergunta ao Tutor Auxiliar:
quantos alunos não fizeram [fórum,tarefa,diário,questionário] ?
quais alunos não fizeram o [fórum,tarefa,diário,questionário] ?
quem não fez o [fórum,tarefa,diário,questionário] ?
nome do aluno] fez a [fórum,tarefa,diário,questionário] ?
quais atividades [nome do aluno] não fez ?
A aluna [nome da aluna] fez o [fórum,tarefa,diário,questionário] ?
Fechar Ajuda

Fig. 6. Web page with manners of making questions

According to the Distant Tutor the answers supplied by the Assistant Tutor helped him identify the students who were up to date with their assignments as well as those who were not. The Distant Tutor sent a reminder message to those students who had not accomplished their assignments. When comparing the work of the Distant Tutor that used MAS with other without the same tool, we noticed the remarkable usefulness of this resource. With the use of MAS the Distant Tutor was able to locate the pending activities of each student in a much shorter period of time.

Architecture Limitation

The experiment showed that the use of AIML is not effective in providing answers to the students. However, it shows the effectiveness of its rules if applied to other different courses, because we can enjoy the same rules for various courses running in the same period.

The MAS does not interact directly with students. It was created to help the Distant Tutor. Therefore it stimulates collaboration among the participants, which is a very important issue in the use of VLEs. This exchange can generate many great learning outcomes for the course and exert a positive influence over students' studies.

Conclusions

In this experiment we confirmed that changes are necessary to the architecture and performance in order to achieve better results. The different modifications and improvements made during the evaluations also showed

that we can design more functional and pro-activity agents. After analyzing the experiment, we can see the contributions provided by the MAS to the students and to the distant tutor, saved time, made for better feedback and better collaboration in the VLE.

It is important to emphasize that this experiment was conducted with only one group. Since we did not have enough volunteers, we reiterate that the agents did not replace the distant tutors, but helped significantly in the teaching-learning process. They provided more time for the tutors to focus on learning activities, which is fundamental to the success of courses, especially in distance education.

The MAS based on the proposed model contributed to help answering some of the student's main questions. Furthermore, it made recommendations on pending assignments. We can also emphasize that this architecture can be enlarged allowing the inclusion of new agents.

The proposed approach was effectively used in the validation of a real course. Also, through the experiment we noticed that the use of the concept of perception resulted in an improvement of the assignments monitoring.

In the future we hope to improve the design of this study's architecture and perform MAS tests based on new ways of interaction among the agents. We intend to continue applying MAS in Distance Education Courses of several teaching institutions.

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